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(54) **APPARATUS AND METHOD FOR CHANGING FREQUENCY DEVIATION**

(71) Applicant: **Continental Automotive Systems, Inc.**, Auburn Hills, MI (US)

(72) Inventors: **Jean-Christophe Deniau**, Fenton, MI (US); **Brian J Farrell**, Troy, MI (US)

(73) Assignee: **Continental Automotive Systems, Inc.**, Auburn Hills, MI (US)

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(51) **Int. Cl.**

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H04L 27/12	(2006.01)
H04W 72/04	(2009.01)
H04L 27/10	(2006.01)
B60C 23/04	(2006.01)

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CPC ***H04W 72/0453*** (2013.01); ***B60C 23/0462*** (2013.01); ***H04L 27/10*** (2013.01)

(58) **Field of Classification Search**
CPC B60C 23/0408
USPC 375/303
See application file for complete search history.

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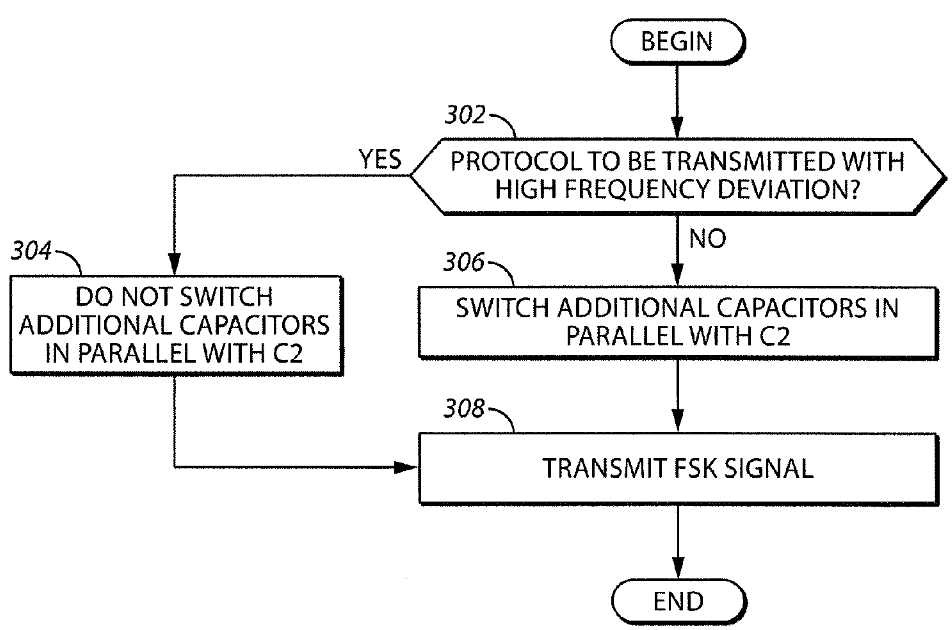
Primary Examiner — Sam K Ahn
Assistant Examiner — Fabricio R Murillo Garcia

(57) **ABSTRACT**

A protocol to be used in the transmission is determined. Based upon the protocol, the transmission frequency range of a clock is selectively altered. TPMS data is transmitted according to the altered transmission frequency range of the clock.

19 Claims, 4 Drawing Sheets



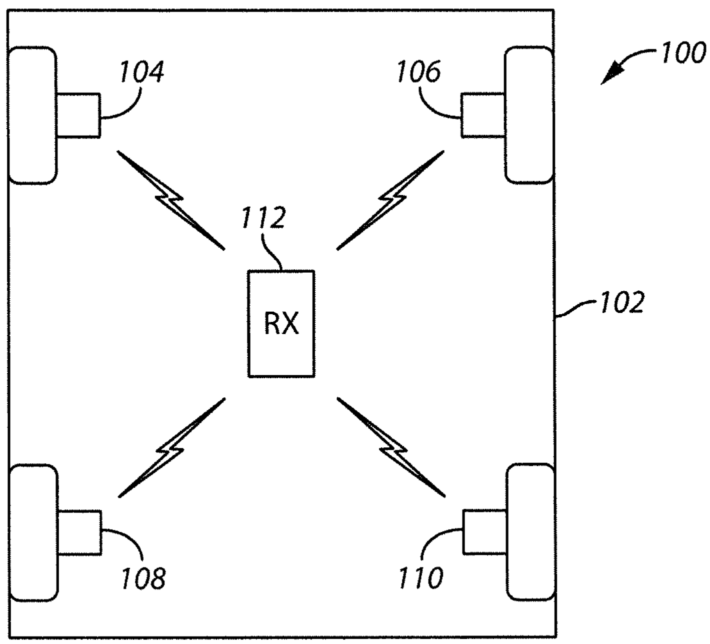


FIG. 1

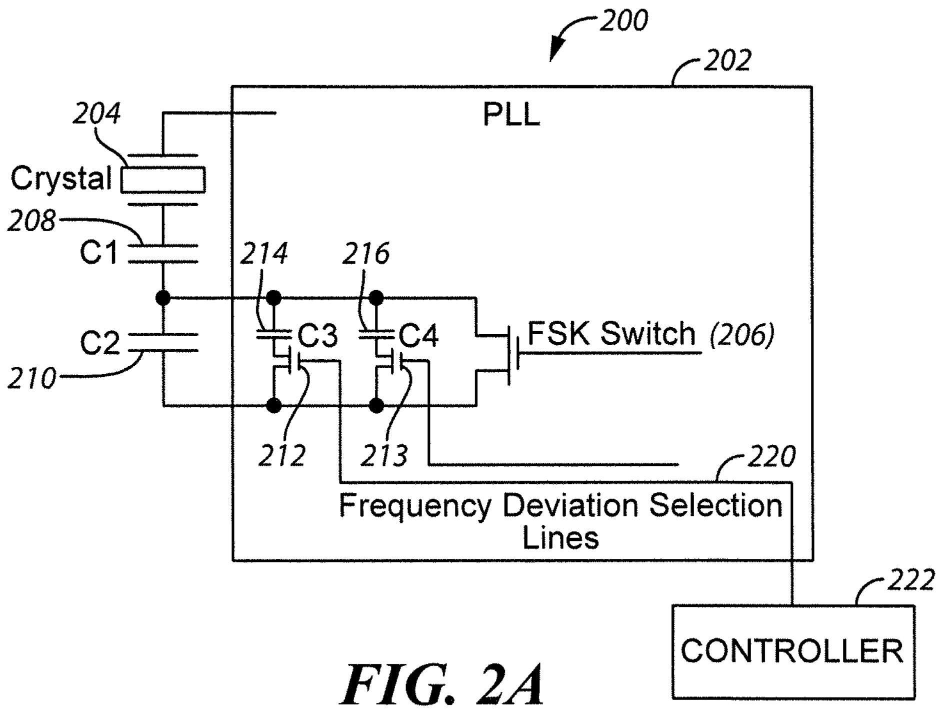

200
202
PLL
204
Crystal
208
C1
214
216
C3
C4
FSK Switch (206)
C2
210
212
213
220
Frequency Deviation Selection
Lines
222
CONTROLLER

FIG. 2A

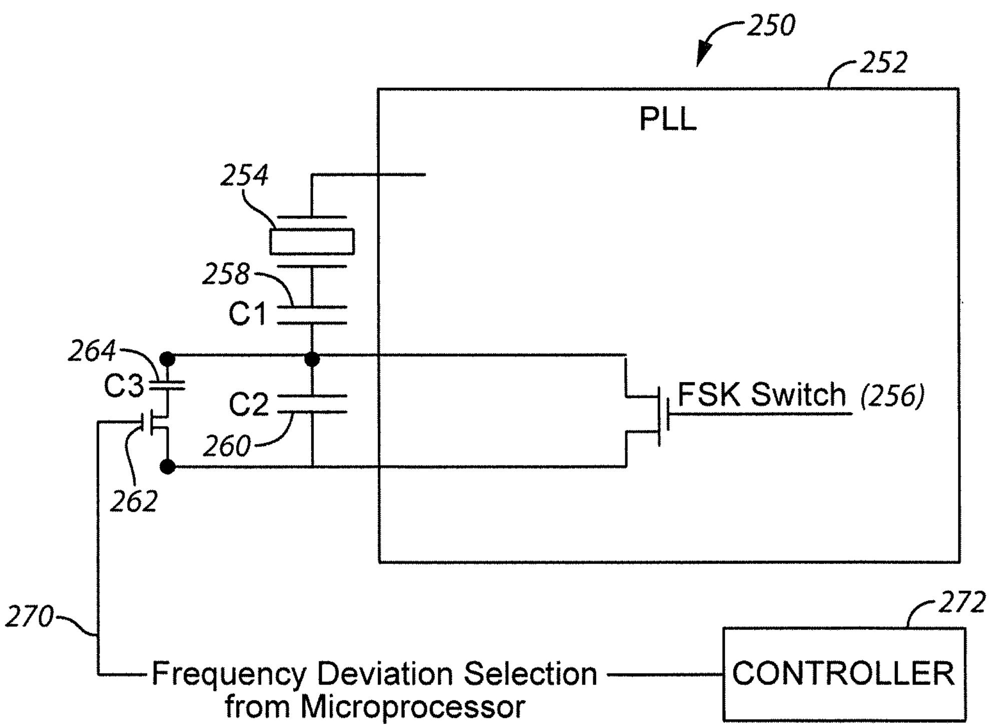

250
252
PLL
254
258
C1
264
C3
C2
FSK Switch (256)
260
262
270
Frequency Deviation Selection
from Microprocessor
272
CONTROLLER

FIG. 2B

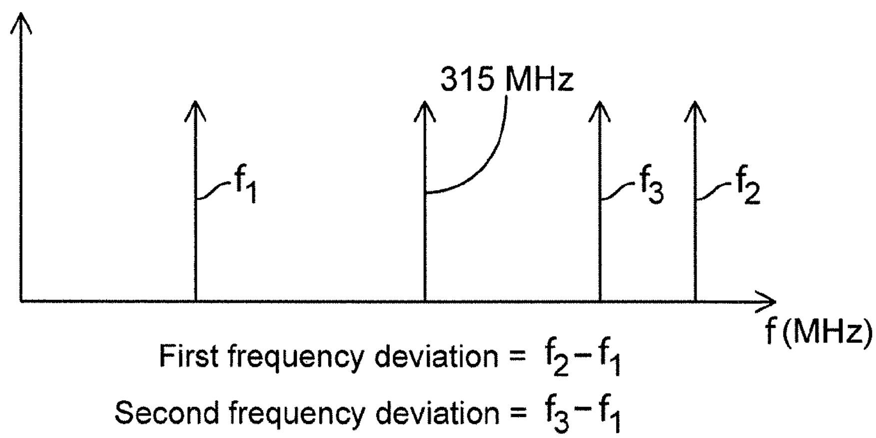

315 MHz
f_1
f_3
f_2
f (MHz)
First frequency deviation = $f_2 - f_1$
Second frequency deviation = $f_3 - f_1$

FIG. 2C

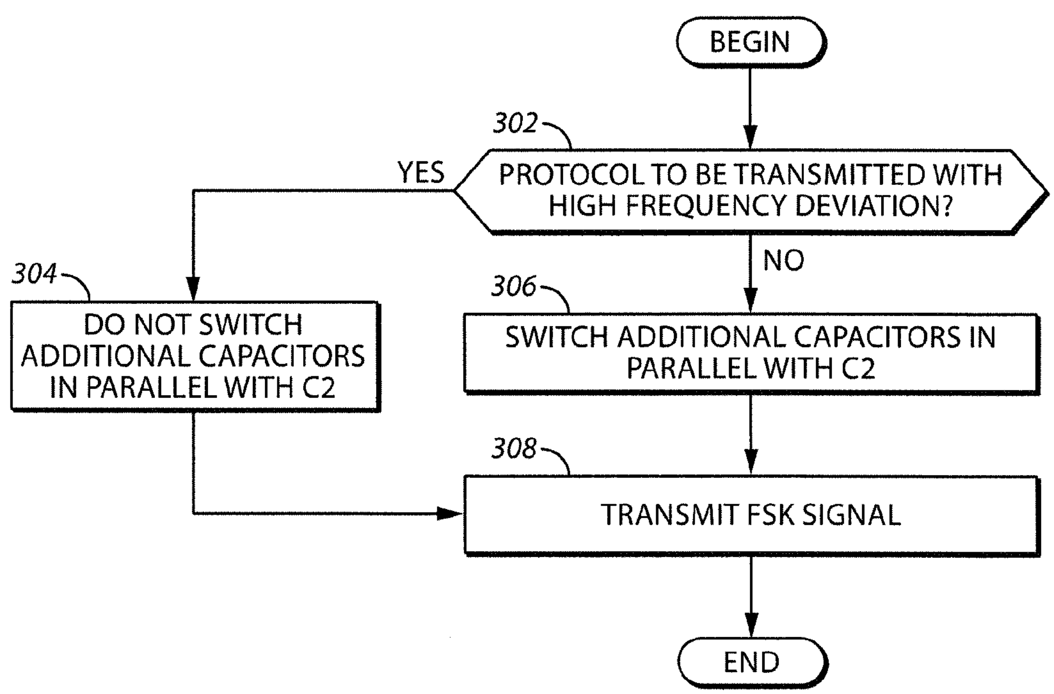

BEGIN
302
PROTOCOL TO BE TRANSMITTED WITH HIGH FREQUENCY DEVIATION?
YES
NO
304
DO NOT SWITCH ADDITIONAL CAPACITORS IN PARALLEL WITH C2
306
SWITCH ADDITIONAL CAPACITORS IN PARALLEL WITH C2
308
TRANSMIT FSK SIGNAL
END

FIG. 3

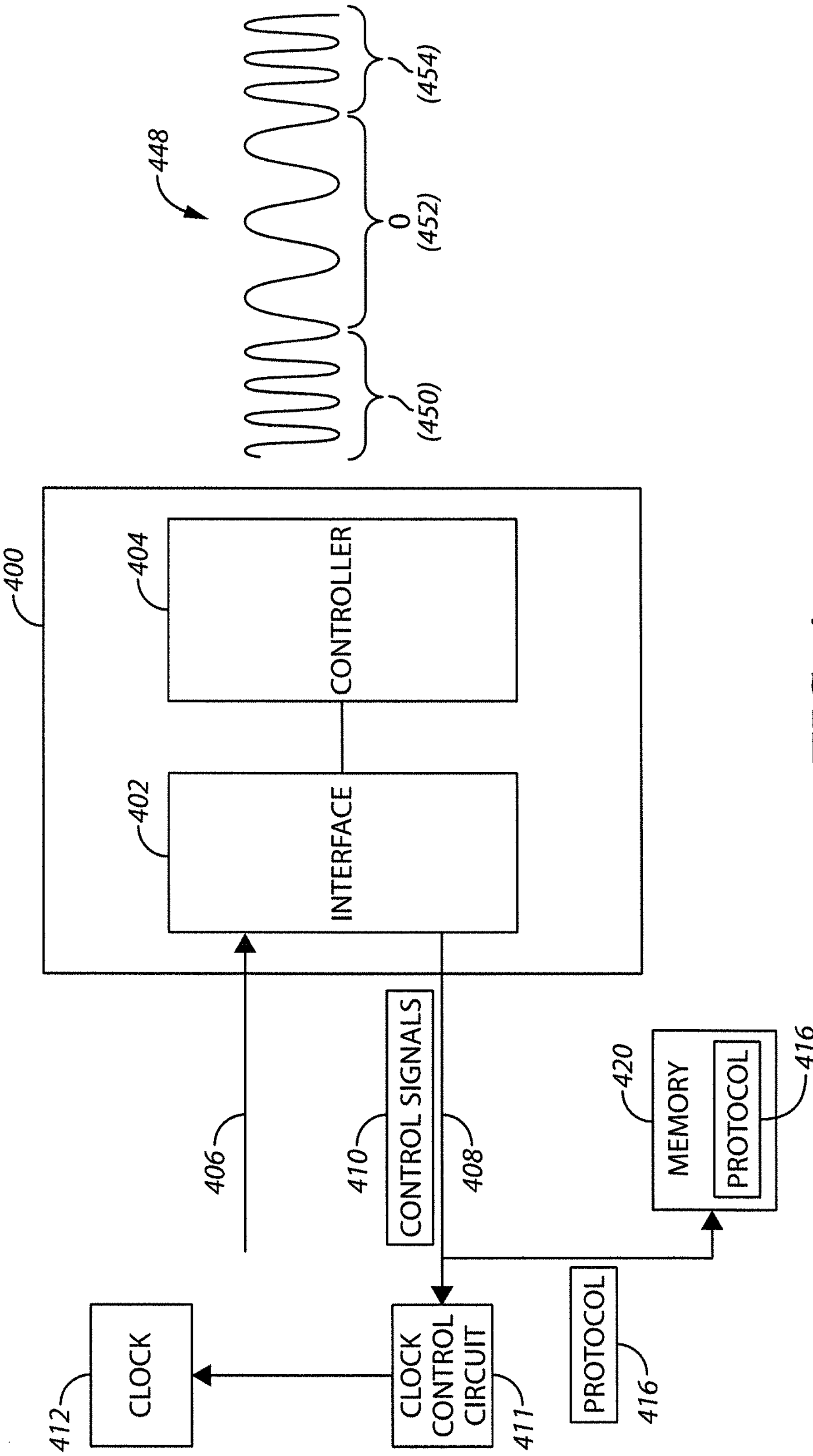

448
(454)
0
(452)
(450)
400
404
CONTROLLER
402
INTERFACE
406
410
CONTROL SIGNALS
408
420
MEMORY
PROTOCOL
416
CLOCK
412
CLOCK CONTROL CIRCUIT
411
PROTOCOL
416

FIG. 4

APPARATUS AND METHOD FOR CHANGING FREQUENCY DEVIATION

TECHNICAL FIELD

This application relates to tire pressure sensors and, more specifically transmissions made to and from these devices.

BACKGROUND OF THE INVENTION

Tire pressuring monitoring (TPM) devices are used in today's vehicles. A tire pressure sensor senses the tire pressure reading (or other conditions, such as the temperature of the tire). These sensed readings may be communicated to a TPM receiver that is disposed in the vehicle. A display screen may also be coupled to the receiver. When the tire pressure reading falls below a particular threshold, the driver of the vehicle may be alerted, for example, by an alert message being displayed to the driver on the screen. The driver can then take any required action.

Most TPM sensors have a specific frequency deviation when they transmit frequency-shift keying (FSK) data. For example, the frequency deviation may be 315 Mhz+/−20 hz or 40 khz of deviation (or range). Thus, 314.98 Mhz may be used for transmission of a logic "0" (in the FSK scheme) while 315.02 Mhz may represent a logic 1. The exact frequency deviation is chosen when the TPM sensor is engineered and must be in accordance with the bandwidth and frequency discrimination of the receiver used to receive the FSK data.

Many TPM sensors have a FSK frequency deviation of between +/−30 Khz to +/−50 Khz. This means that the bandwidth of the receiver must be around 200 kHz. A wide receiver bandwidth is cost effective, but is linked to more in-band noise coming from different sources. This in-band noise decreases the sensitivity of the sensor in some cases.

Some original equipment manufacturers (OEMs) require a smaller bandwidth receiver. Thus, the TPM sensor working with such a receiver must also limit its frequency deviation. In some cases, a TPM sensor with a wide frequency deviation may not be received at all by a narrow band receiver or can be attenuated.

BRIEF DESCRIPTION OF THE DRAWINGS

For a more complete understanding of the disclosure, reference should be made to the following detailed description and accompanying drawings wherein:

FIG. **1** comprises a block diagram of a system that changes FSK frequency deviation on the fly according to various embodiments of the present invention;

FIG. **2**A comprises a block diagram of a FSK switching arrangement for a TPMS monitor with capacitors inside the PLL according to various embodiments of the present invention;

FIG. **2**B comprises a block diagram of a FSK switching arrangement for a TPMS monitor with capacitors outside the PLL according to various embodiments of the present invention;

FIG. **2**C comprises a frequency response graph showing frequency deviations according to various embodiments of the present invention;

FIG. **3** comprises a flowchart of an approach for FSK switching according to various embodiments of the present invention;

FIG. **4** comprises a block diagram of an apparatus that changes FSK frequency deviation on the fly according to various embodiments of the present invention.

Skilled artisans will appreciate that elements in the figures are illustrated for simplicity and clarity. It will further be appreciated that certain actions and/or steps may be described or depicted in a particular order of occurrence while those skilled in the art will understand that such specificity with respect to sequence is not actually required. It will also be understood that the terms and expressions used herein have the ordinary meaning as is accorded to such terms and expressions with respect to their corresponding respective areas of inquiry and study except where specific meanings have otherwise been set forth herein.

DETAILED DESCRIPTION

Approaches are provided that implement a frequency-shift keying (FSK) frequency deviation switch for multi-application tire pressure monitoring (TPM) sensors or for any different radio frequency (RF) transmitters requiring different frequency deviations. The frequency deviation of the transmitted FSK signal is adjusted based upon the protocol to be transmitted. The TPMS sensors (or monitors or wheel units) may include processing devices and memories and execute computer instructions to sense and transmit tire pressure (or other) data. In these regards, the TPMS sensors may themselves include structures, devices, or apparatus that actually sense the pressure (or other types of data) in the tire, and make transmissions of the sensed information.

In one aspect, the TPM sensor uses a phase locked loop (PLL) to modulate and transmit the FSK data to the receiver. In some cases, the PLL offers the ability to use internal capacitors instead of external capacitors to create the desired frequency deviation. Typically, TPM sensor manufacturers prefer to use external load capacitors to the crystal oscillator as these represent fixed values.

In the present approaches, a bank of capacitors is offered by a PLL of the TPM sensor and this bank of capacitors can be either switched on or off depending upon the frequency deviation that is required. The bank of capacitors can be implemented with discrete components.

In many of these embodiments, a protocol that is to be used in the transmission is determined. Based upon the protocol, the transmission frequency range (or deviation) of a clock is selectively altered. TPMS data is transmitted according to the altered transmission frequency range (or deviation) of the clock.

In some aspects, selected ones of a plurality of capacitors that are coupled to the clock are selectively switched in and out of the transmission circuit. In other aspects, the transmissions are performed according to a frequency-shift keying (FSK) approach. In still other examples, the protocol is a selected protocol from a plurality of protocol and each of the plurality of protocols is associated with a different automobile manufacturer.

In other aspects, the clock is a crystal oscillator. In yet other aspects, the approaches are performed by a phase-locked loop (PLL).

In others of these embodiments, an apparatus for transmitting tire pressuring monitoring system (TPMS) data includes an interface and a controller. The interface has an input and an output. The controller is coupled to the interface. The controller is configured to determine a protocol to be used in the transmission and, based upon the protocol, selectively produce control signals that alter the transmission frequency range (or deviation) of a clock. The controller is further configured to transmit TPMS data according to the altered transmission frequency range (or deviation) of the clock at the output.

Referring now to FIG. **1**, a system **100** that changes FSK frequency deviation on the fly for a multi-application TPMS sensor is described. The system **100** includes a first TPMS monitor (or sensor or unit or wheel unit) **104**, a second TPMS monitor **106**, a third TPMS monitor **108**, and a fourth TPMS monitor **110**. The monitors **104**, **106**, **108**, and **110** communicate with a receiver **112**. The communication between the TPMS monitors **104**, **106**, **108**, and **110** and the receiver **112** is accomplished in one aspect via wireless, radio frequency (RF) links.

The TPMS monitors **104**, **106**, **108**, and **110** may include processing devices and memories and execute computer instructions to sense and transmit tire pressure (or other) data. In these regards, the TPMS monitors **104**, **106**, **108**, and **110** may themselves include structures, devices, or apparatus that actually sense the pressure (or other types of data) in the tire.

The receiver **112** includes hardware and/or software to receive (and in some examples transmit) information from the TPMS monitors **104**, **106**, **108**, and **110**. The receiver **112** is disposed at an appropriate location within the vehicle **102**.

The TPMS monitors **104**, **106**, **108**, and **110** each implement at a minimum a FSK frequency deviation switch and are multi-application sensors. The sensors may also attenuate using amplitude-shift keying (ASK). That is, the monitors can change frequency deviation on the fly. In other words, the frequency deviation or range of the transmitted FSK signals from the TPMS monitors **104**, **106**, **108**, and **110** are adjusted based upon the protocol to be transmitted.

In one aspect, the TPMS monitors **104**, **106**, **108**, and **110** utilize a phase locked loop to modulate and transmit the FSK data to the receiver **112**. In some cases, the PLL offers the ability to use internal capacitors instead of external capacitors to create the desired frequency deviation. More specifically, a bank of capacitors is offered by a PLL and this bank of capacitors can be either switched on or off depending upon the frequency deviation that is required. The bank of capacitors can be implemented using discrete components.

Referring now to FIGS. **2**A and **2**C, one example of a circuit **200** for changing FSK frequency deviation on the fly is described. The circuit **200** includes a phase locked loop (PLL) **202**, a clock (e.g., crystal oscillator) **204**, a FSK switch **206**, a first capacitor (C**1**) **208**, a second capacitor (C**2**) **210**, a first frequency deviation selection switch **212**, a second frequency deviation selection switch **213**, a third capacitor (C**3**) **214**, and a fourth capacitor (C**4**) **216** where C**1**, C**2**, C**3** and C**4** are the values of the capacitors.

The oscillator **202** oscillates at a certain frequency. If a high signal (a “1”) is applied to the FSK switch **206**, the switch **206** closes and the second capacitor (C**2**) **210** is shorted. A low “tone” with frequency equal to f**1** is transmitted. If a low signal (a logic “0”) is applied to the FSK switch **206**, the switch **206** is open and the second capacitor (C**2**) **210** is not shorted. A high “tone” with frequency equal to f**2** can also be transmitted. F**2** is higher than f**1** because the equivalent capacitance (CA) is (C**1**)(C**2**)/(C**1**+C**2**) and this is less than C**1**. Consequently, f**2** is greater than f**1**. The frequency deviation is f**2**−f**1**. These examples assume low signals are applied to the first frequency deviation selection switch **212** and the second frequency deviation selection switch **213**.

If a smaller frequency deviation is desired, f**1** remains the same since it is driven by C**1**. F**2** is changed to a smaller value (f**3**) so the frequency deviation (f**3**−f**1**) is smaller than f**2**−f**1**. In particular, a high signal is applied to first frequency deviation selection switch **212**, a low signal is applied to the second frequency deviation selection switch **213**, and a low signal is applied to FSK switch **206**. Then, the equivalent capacitance (CB) becomes C**1**/(C**2**+C**3**). 1/CB=1/C**1**+1/(C**2**+C**3**)=(C**2**+C**3**)/C**1**(C**2**+C**3**)+C**1**/C**1**(C**1**(C**2**+C**3**)=(C**1**+C**2**+C**3**)/C**1**C**2**+C**1**C**3**. Thus, CB=(C**1**C**2**+C**1**C**3**)/(C**1**+C**2**+C**3**). CB is greater than CA. Thus f**3** (the new “High tone” frequency is less than f**2**. With the first frequency deviation being f**2**−f**1**, and the second deviation (with the addition of the capacitor bank being f**3**−f**1**, it can be appreciated that the second frequency deviation is less than the first frequency deviation. The fourth capacitor **216** may also be added to decrease the deviation further. Alternatively, the third capacitor **214** may be switched out and the fourth capacitor **216** switched in to give another frequency deviation.

The controller **222** determines when to switch in or out third capacitor **214** (via line **220**) and the fourth capacitor **216**. In this example, the third capacitor **214** and the fourth capacitor **216** are located in the PLL **202**. Similarly, controller **272** and line **270** in FIG. **2**B provide frequency deviation selection.

Referring now to FIGS. **2**B and **2**C, another example of a circuit **250** for changing FSK frequency deviation on the fly is described. The circuit **250** includes a phase locked loop (PLL) **252**, a clock (e.g., crystal oscillator) **254**, a FSK switch **256**, a first capacitor (C**1**) **258**, a second capacitor (C**2**) **260**, a frequency deviation selection switch **262**, and a third capacitor (C**3**) **264**. C**1**, C**2**, C**3** and C**4** are the values of the capacitors.

The oscillator **252** oscillates at a certain frequency. If a high signal (a “1”) is applied to the FSK switch **256**, the switch **256** closes and the second capacitor (C**2**) **260** is shorted. A low “tone” with frequency equal to f**1** is transmitted. If a low signal (a logic “0”) is applied to the FSK switch **256**, the switch **256** is open and the second capacitor (C**2**) **260** is not shorted. A high “tone” with frequency equal to f**2** can also be transmitted. F**2** is higher than f**1** because the equivalent capacitance (CA) is (C**1**)(C**2**)/(C**1**+C**2**) and this is less than C**1**. Consequently, f**2** is greater than f**1**. The frequency deviation is f**2**−f**1**. These examples assume low signals are applied to the frequency deviation selection switch **262**.

If a smaller frequency deviation is desired, f**1** remains the same since it is driven by C**1**. F**2** is changed to a smaller value (f**3**) so the frequency deviation (**1341**) is smaller than f**2**−f**1**. In particular, a high signal is applied to frequency deviation selection switch **262**, and a low signal is applied to FSK switch **256**. Then, the equivalent capacitance (CB) becomes C**1**/(C**2**+C**3**). 1/CB=1/C**1**+1/(C**2**+C**3**)=(C**2**+C**3**)/C**1**(C**2**+C**3**)+C**1**/C**1**(C**1**(C**2**+C**3**)=(C**1**+C**2**+C**3**)/C**1**C**2**+C**1** C**3**. Thus, CB=(C**1**C**2**+C**1**C**3**)/(C**1**+C**2**+C**3**). CB is greater than CA. Thus f**3** (the new “High tone” frequency is less than f**2**. With the first frequency deviation being f**2**−f**1**, and the second deviation (with the addition of the capacitor bank being f**3**−f**1**, it can be appreciated that the second frequency deviation is less than the first frequency deviation. Other capacitors may be added in parallel to the third capacitor (C**3**) **256** and as showed in the example of FIG. **2**A.

As shown in both FIG. **2**A and FIG. **2**B, the PLL **202** and **252** provides a fixed frequency deviation. The first capacitor **208** or **258** (C**1**) is the load capacitor for the crystal oscillator **204** or **254** resulting in the lower carrier of the FSK signal. During the low carrier transmission, the FET (FSK switch) **206** or **256** shorts the second capacitor **210** or **260** (C**2**) to ground. For the high frequency carrier, the FET switch **206** or **256** is opened and the second capacitor **210** or **260** (C**2**) is in series with the first capacitor **208** or **258** (C**1**) creating a different load on the crystal and a different carrier transmission frequency.

Referring now to FIG. **3**, one example of an approach for FSK switching is described. At step **302**, it is determined if the protocol to transmit includes a high frequency deviation. For example, a threshold may be used and if the transmission protocol has a frequency deviation that exceeds this threshold then the step is answered in the affirmative. On the other hand, if the desired protocol falls below the threshold then the answer is negative.

If the answer at step **302** is affirmative, then at step **304** additional capacitors in parallel with a loading capacitor (e.g., the second capacitor **208** or **258** in FIG. **2**A and FIG. **2**B) are not switched in parallel with the loading capacitor. This action maintains a relatively high frequency deviation.

If the answer at step **302** is affirmative, then at step **306** additional capacitors in parallel with a loading capacitor (e.g., the second capacitor **208** or **258** in FIG. **2**A and FIG. **2**B) are switched in parallel with the loading capacitor. This action decreases a high frequency deviation. For example, if the center frequency is 315+/−20 khz, this action may decrease the deviation to +/−10 khz. In this way, the approaches accommodate a frequency range that the receiver in the vehicle is expecting.

Referring now to FIG. **4**, an apparatus **400** for transmitting tire pressuring monitoring system (TPMS) data includes an interface **402** and a controller **404**. The interface **402** has an input **406** and an output **408**.

The controller **404** is coupled to the interface **402**. The controller **404** is configured to determine a protocol **416** to be used in the transmission and, based upon the protocol **416**, selectively produce control signals **410** that alter the transmission frequency of a clock **412**. The protocol **416** may be received from a memory **420** at the input **406**. The controller **404** is further configured to transmit TPMS data **414** according to the altered transmission frequency of the clock **412** at the output **408**. The control signals **408** may control a control circuit **411** that actually changes the clock frequency.

Still referring to FIG. **4**, a transmission **448** is shown and includes a first portion **450**, a second portion **452**, and a third portion **454**. The first portion **450** is at a high frequency and represents a logic 1; the second portion **452** is at a lower frequency and represents a logic 0, and the third portion **454** is at the same high frequency as the first portion **450** and also represents a logic 1.

In the approaches described herein the range or deviation between high and low frequencies is altered on the fly based upon the protocol needed. For example, the difference between high frequency (of portions **450** and **454**) and low frequency (portion **454**) may need to be 20 khz for some transmission protocols and 30 khz for other protocols. As described herein, capacitors in a capacitor bank may be switched in or out of the transmission circuit. This switching of capacitors alters the "High tone" or high transmission frequency. Thus, if initially the low transmission frequency is f**1**, and the high transmission frequency is f**2** (f**2**>f**1**), then the deviation is f**2**−f**1**. Inserting a capacitor into the transmission circuit changes f**2** to f**3** with f**3**<f**2** and f**1**<f**3**. Thus, the second frequency deviation is f**3**−f**1** and the second frequency deviation is less than the first frequency deviation.

As mentioned, the frequency deviation used can be selected according to the protocol used. By protocols, it is meant any parameter or group of parameters or characteristics that describes a transmission including, for example, data formats (e.g., positioning and meaning of bits), baud rates, to mention two examples. Other examples are possible.

It should be understood that any of the devices described herein (e.g., the programming or activation devices, PLLs, the wheel units, the controllers, the receivers, the transmitters, the sensors, any presentation devices, or the external devices) may use a computing device to implement various functionality and operation of these devices. In terms of hardware architecture, such a computing device can include but is not limited to a processor, a memory, and one or more input and/or output (I/O) device interface(s) that are communicatively coupled via a local interface. The local interface can include, for example but not limited to, one or more buses and/or other wired or wireless connections. The processor may be a hardware device for executing software, particularly software stored in memory. The processor can be a custom made or commercially available processor, a central processing unit (CPU), an auxiliary processor among several processors associated with the computing device, a semiconductor based microprocessor (in the form of a microchip or chip set) or generally any device for executing software instructions.

The memory devices described herein can include any one or combination of volatile memory elements (e.g., random access memory (RAM), such as dynamic RAM (DRAM), static RAM (SRAM), synchronous dynamic RAM (SDRAM), video RAM (VRAM), and so forth)) and/or nonvolatile memory elements (e.g., read only memory (ROM), hard drive, tape, CD-ROM, and so forth). Moreover, the memory may incorporate electronic, magnetic, optical, and/or other types of storage media. The memory can also have a distributed architecture, where various components are situated remotely from one another, but can be accessed by the processor.

The software in any of the memory devices described herein may include one or more separate programs, each of which includes an ordered listing of executable instructions for implementing the functions described herein. When constructed as a source program, the program is translated via a compiler, assembler, interpreter, or the like, which may or may not be included within the memory.

It will be appreciated that any of the approaches described herein can be implemented at least in part as computer instructions stored on a computer media (e.g., a computer memory as described above) and these instructions can be executed on a processing device such as a microprocessor. However, these approaches can be implemented as any combination of electronic hardware and/or software.

Preferred embodiments of this invention are described herein, including the best mode known to the inventors for carrying out the invention. It should be understood that the illustrated embodiments are exemplary only, and should not be taken as limiting the scope of the invention.

What is claimed is:

1. A method for transmitting frequency-shift keying (FSK)-based tire pressuring monitoring system (TPMS) data, comprising,

at a first time and at a single tire pressure monitoring (TPM) sensor, determining a first protocol to be used in the transmission of tire pressure monitoring data from a transmitter;

based upon the first protocol, selecting a first deviation between a first high frequency that is used to transmit a logic one and a first low frequency to transmit a logic zero;

wherein the first deviation is selected at least in part by comparing a first deviation threshold with a first high frequency deviation associated with the first protocol;

transmitting the FSK-based TPMS data according to the first high frequency when there is a logic one and first low frequency when there is a logic zero;

at a second time that occurs after the first time and at the same TPM sensor, subsequently determining a second protocol to be used in the transmission of tire pressure monitoring data from the transmitter;

based upon the second protocol, selecting a second deviation between a second high frequency that is used to transmit a logic one and a second low frequency to transmit a logic zero;

wherein the second deviation is selected at least in part by comparing a second deviation threshold with a second high frequency deviation associated with the second protocol;

wherein the first deviation is different than the second deviation;

transmitting FSK-based TPMS data according to the second high frequency when there is a logic one and second low frequency when there is a logic zero;

wherein the first protocol is switched to the second protocol on-the-fly at the single TPM sensor during the operation of the TPM sensor;

wherein the first protocol and the second protocol comprise one or more of a data format or baud rate;

wherein the first protocol and the second protocol are determined at least in part by a controller.

2. The method of claim **1** wherein the change from the first high frequency to the second high frequency, and from the first low frequency to the second low frequency is realized by selectively switching in or out selected ones of a plurality of capacitors.

3. The method of claim **1** wherein the first high frequency and the second high frequency are the same.

4. The method of claim **1** wherein the first and second protocols are selected from a plurality of protocols, each of the plurality of protocols associated with a different automobile manufacturer.

5. The method of claim **1** wherein the first low frequency and the second low frequency are the same.

6. The method of claim **1** wherein at least some of the steps are performed by a phase-locked loop (PLL).

7. The method of claim **1**, wherein at least some of the steps are performed at a wheel unit.

8. An apparatus for transmitting frequency-shift keying (FSK)-based tire pressuring monitoring system (TPMS) data, comprising,

an interface having an input and an output;

a controller coupled to the interface, the controller configured to determine at a first time a first protocol to be used in the transmission of tire pressure monitoring data from a transmitter, and based upon the first protocol, select a first deviation between a first high frequency that is used to transmit a logic one and a first low frequency to transmit a logic zero, wherein the first deviation is selected at least in part by comparing a first deviation threshold with a first high frequency deviation associated with the first protocol, the controller configured to transmit the FSK-based TPMS data according to the first high frequency when there is a logic one and first low frequency when there is a logic zero, the controller configured to at a second time that occurs after the first time subsequently determine a second protocol to be used in the transmission of tire pressure monitoring data from the transmitter, and based upon the second protocol, select a second deviation between a second high frequency that is used to transmit a logic one and a second low frequency to transmit a logic zero, wherein the second deviation is selected at least in part by comparing a second deviation threshold with a second high frequency deviation associated with the second protocol, wherein the first deviation is different than the second deviation, the controller configured to transmit TPMS data according to the second high frequency when there is a logic one and second low frequency when there is a logic zero;

wherein the first protocol is switched to the second protocol on-the-fly at the single TPM sensor during the operation of the TPM sensor;

wherein the first protocol and the second protocol comprise one or more of a data format or baud rate.

9. The apparatus of claim **8** wherein the control signals are effective to change the first high frequency to the second high frequency, and the first low frequency to the second low frequency by selectively switching in or out selected ones of a plurality of capacitors.

10. The apparatus of claim **8** wherein the first high frequency and the second high frequency are the same.

11. The apparatus of claim **8** wherein the first and second protocols are selected from a plurality of protocols, each of the plurality of protocols associated with a different automobile manufacturer.

12. The apparatus of claim **8** wherein the first low frequency and the second low frequency are the same.

13. The apparatus of claim **8** wherein the apparatus is disposed at a wheel unit.

14. A computer usable non-transitory medium having a computer readable program code embodied therein, said computer readable program code adapted to be executed to implement a method of transmitting frequency-shift keying (FSK)-based tire pressure monitor information, the method comprising:

at a first time and at a tire pressure monitoring (TPM) sensor, determining a first protocol to be used in the transmission of tire pressure monitoring system (TPMS) data;

based upon the first protocol, selecting a first deviation between a first high frequency that is used to transmit a logic one and a first low frequency to transmit a logic zero;

wherein the first deviation is selected at least in part by comparing a first deviation threshold with a first high frequency deviation associated with the first protocol;

transmitting the FSK-based TPMS data according to the first high frequency when there is a logic one and first low frequency when there is a logic zero;

at a second time that occurs after the first time and at the same TPM sensor, subsequently determining a second protocol to be used in the transmission of tire pressure monitoring data from the transmitter;

based upon the second protocol, selecting a second deviation between a second high frequency that is used to transmit a logic one and a second low frequency to transmit a logic zero;

wherein the second deviation is selected at least in part by comparing a second deviation threshold with a second high frequency deviation associated with the second protocol;

wherein the first deviation is different than the second deviation;

transmitting the FSK-based TPMS data according to the second high frequency when there is a logic one and second low frequency when there is a logic zero;

wherein the first protocol is switched to the second protocol on-the-fly at the single TPM sensor during the operation of the TPM sensor;

wherein the first protocol and the second protocol comprise one or more of a data format or baud rate;

wherein the first protocol and the second protocol are determined at least in part by a controller.

15. The computer medium of claim **14** wherein the change from the first high frequency to the second high frequency, and from the first low frequency to the second low frequency are realized by selectively switching in or out selected ones of a plurality of capacitors.

16. The computer medium of claim **14** wherein the first high frequency and the second high frequency are the same.

17. The computer medium of claim **14** wherein the first and second protocols are selected from a plurality of protocols, each of the plurality of protocols associated with a different automobile manufacturer.

18. The computer medium of claim **14** wherein the first low frequency and the second low frequency are the same.

19. The computer medium of claim **14** wherein at least some of the steps are performed by a phase-locked loop (PLL).

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